Navigating the Digital Classroom: A Comparative Analysis of Sociomaterial vs. Cognitive Approaches to Understanding Learning Experiences in Online Education

Luke Hendrik Hackenberg

s4745051

Department of Psychology, University of Groningen

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Supervisor: (prof.) Haros Psaros

Second evaluator: (dr.) Miquel Garcia Pimenta

In collaboration with: Isa Borst, Kjell Dantzer, Daniel Eshuis, and Romano Liu

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Abstract

Online learning has become a key component of educational institutions. The rapid shift to online learning since the COVID-19 pandemic has shown the need for effective online educational technologies. This paper explores the differences between sociomaterial and cognitive approaches in understanding learning experiences in online education, focusing on their implications for the design and effectiveness of online education. A literature analysis was conducted to understand the differences between these paradigms and the implications resulting from them. While cognitive approaches focus on the individual and their mental processes, such as working memory, cognitive load, and dual coding theory, in the learning process, sociomaterial approaches do not distinguish between humans and non-human actors and view learning as an interconnected process involving social and material factors. The intra-action between these entities is defined as the learning process, and learning outcomes emerge from this intra-action rather than being pre-established. Therefore, the implications for the design of effective online technologies differ in that cognitivists aspire to create tools that ease the engagement and learning process of an individual, while sociomaterialists focus on creating a rich interactional space which enhances engagement and learning outcomes. Based on these findings, it was concluded that both paradigms offer valuable insights into the design and implementation of online educational technology and that future research needs to focus on integrating both paradigms to create more effective and inclusive educational experiences.

Keywords: sociomaterial approaches, cognitive approaches, online learning, educational technologies, engagement

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In 2019, an unexpected outbreak of a highly contagious illness known as COVID-19, caused by the coronavirus (SARS-CoV-2), had a significant impact on the entire world (Naseer et al., 2023; WHO, 2021). With a death toll exceeding two million people and over a hundred million individuals falling into extreme poverty, many countries are still struggling with the aftermath of this event (WHO, 2021). Beyond its consequences on economies and healthcare systems, the COVID-19 pandemic has left a noticeable mark on the education of more than one and a half billion people worldwide (UNESCO, 2020). The COVID-19 pandemic forced educational institutions to switch to online approaches to guarantee their programmes' continuance and prevent possible learning gaps (Dhawan, 2020; Sultanova et al., 2021).

This switch enabled educational institutions to appreciate the advantages of online teaching methods. Online learning allows students to customise their learning experience based on their personal needs and preferences (Sunal & Wright, 2012; Swerdloff, 2016). This is especially interesting for non-traditional students, such as working individuals or adult learners, who may require flexible schedules to balance their studies with other responsibilities. Additionally, online learning platforms are becoming increasingly effective and efficient thanks to better working technologies. These platforms offer learning algorithms, simulations, and analytic tools to optimise learning experiences and improve learning outcomes (Sunal & Wright, 2012; Swerdloff, 2016). As a result, online education is playing a central role in modern learning and has become a key component of educational institutions. Several approaches explain this learning paradigm, and this paper will focus on two important ones: the sociomaterial and cognitive approaches. While both paradigms attempt to demonstrate the importance of this learning model, comparative analyses between them are scarce. Thus, critically reflecting on these two prominent approaches will help us understand the mechanisms behind online learning as a whole and improve students' online learning experiences.

Sociomaterial Approaches to Learning

As online learning evolves, sociomaterial approaches to online learning have emerged, providing a new perspective on educational processes. To understand the sociomaterial approaches, one must understand where this relatively new approach emerged from (Schlauch, 2020). Initially, learning scholars focused only on the active learner himself. However, they began to emphasise an individual's cultural and historical environment over time. Cole and Vygtosky (1978, as cited in Schlauch, 2020) criticised the prominent view that learning purely happens in the brain and highlighted the importance of the social context. Following that, modern perspectives, such as the sociocultural approach, stress that the social environment is not merely a passive factor but actively shapes an individual's learning experience (Schlauch, 2020).

Building upon foundational tenets of sociocultural theories, sociomaterial approaches further integrate the role of material aspects and social environments in shaping learning experiences (Schlauch, 2020). While sociomaterial approaches are a heterogeneous paradigm consisting of many theories, all sociomaterial theories share one main analytical view: they do not separate *human* and *non-human* dimensions of everyday practices (Decuypere & Simons, 2016). Instead, they look at them in the form of relations and put aside the idea of humans as the centre of the world (Schlauch, 2020). Humans and non-humans are part of a more extensive network and are, therefore, linked (Gherardi, 2017). The change of one of these *actors* influences the other, and Barad (2003) defines this relation as *intra-action*. Non-humans are not longer seen as inactive objects - and thus only an extension of human activities - but as an active part of everyday practices (Sørensen, 2009).

Sociomaterialists do not argue that humans and non-humans are the same; instead, they do not give one of these actors a superior role (Barad, 2003). Accepting the idea of intra-action of humans and non-humans allows us to think differently about knowing. The "knower" is not anymore external or pre-existing in the world, but objects and knowers "emerge through and as part of their entangled intra-relating." (Gherardi, 2017, p. 41). Therefore, learning and teaching are not considered separate processes but a unified teaching-learning continuum (Schlauch, 2020). The teacher is not the sole factor that produces a learning outcome and passes along knowledge but is seen as having a central role in this network, primarily as a connecting link between the tangible elements (the objects) and the student (Montessori, 2004, as cited in Schlauch, 2020).

Furthermore, these connections are formed through heterogeneous *assemblages* of different agencies (Orlikowski, 2007). These assemblages consist of flexible agencies, including human actors, technological artefacts, organisational structures, and cultural norms. They are not equivalent but diverse, involving a mix of elements with different degrees of influence and agency. This again highlights the dynamic and interconnected nature of sociomaterial relationships within educational contexts.

For these reasons, sociomaterial approaches see social and material elements as always entangled in everyday practices (Fenwick, 2015). They emerge from their intra-action (Barad, 2003), and none of them pre-exist in the world (Gherardi, 2017). Neither humans nor non-human technologies play a superior role in learning (Schlauch, 2020), and this network is composed of different active heterogeneous agencies (Orlikowski, 2007). Learning can only be understood by looking at the intra-play between these assemblages and the whole network, not just single actors within it (Montessori, 2004, as cited in Schlauch, 2020).

Cognitive Approaches to Learning

Transitioning from sociomaterial approaches to learning to cognitive approaches, it becomes clear that the latter prioritises the individual in learning processes. Within these frameworks, learning is defined as an internalised process occurring within an individual's brain (Winn, 1982). As identified by Winn (1982), central internal processes include integrating perceptual features, creating and manipulating mental representations, and identifying and classifying concepts. From this perspective, examining individuals' perceptions of external cues becomes necessary to understand how they learn.

According to Gazzaniga (2018), perception happens at an unconscious level, with individuals not always consciously aware of all the *stimuli* they perceive. All sensory inputs we hear, smell, and see are processed and stored in our *perceptual memory*, but the brain filters out some of the information due to its overwhelming nature. Attention to specific stimuli directs relevant stimuli to the working memory, where engagement is necessary to hold them there. If knowledge is found important or relevant, this information is then transferred and encoded into our *long-term memory* for indefinite storage and future retrieval.

To understand how this knowledge is encoded and presented in memory, cognitivists have developed *schema theory*, which suggests that information is encoded and represented in different schemata (Thorndyke & Hayes-Roth, 1979). A schema can be imagined as a category of similar information, like a library bookshelf containing only books from one overall category. When new stimuli are perceived, the individual either integrates them into an existing category or creates a new one. Piaget (1967, as cited in Winn, 1982) called the first process *assimilation* and the second *accommodation*.

Extending schema theory, retrieving stored knowledge involves two fundamental processes: bottom-up and top-down processing (Anderson, 2017). For instance, when a person hears a barking sound while walking through a field, they instinctively process the sound and compare it to stored knowledge, demonstrating bottom-up processing. In contrast, if they are searching for foxes, their brain uses top-down processing, where prior knowledge of foxes shapes their perception and interpretation of sensory information. Thus, these processes illustrate how prior knowledge influences perception and cognition.

Understanding how information is processed also helps explain the differences in how easily knowledge can be retrieved from long-term memory. Some information can be retrieved easily, while other knowledge needs some help from context. The more and better information is understood, the "deeper" information is processed, and therefore, it is learned and remembered better. Superficial levels of processing do not go through more profound levels of memory and are considered poorly learned (Craik & Lockhart, 1972).

While cognitive approaches prioritise the learner in the learning process, this does not mean they do not consider the environment as crucial. They acknowledge the influence of the environment and social interactions on learning outcomes (Nabavi & Bijandi, 2012), describing these outcomes as shaped by the learner's interactions with the environment. Bandura (1999) described this social learning process in his *social cognitive learning theory (SCLT) (*as cited in Mccormick & Martinko, 2004), emphasising that people can learn by observing others, understanding, predicting and changing their behaviour according to them. However, compared to sociomaterial approaches, the learner and their cognitive processes play the central role in this theory (Mccormick & Martinko, 2004).

Thus, cognitivists see learning mainly as an individual process (Winn, 1982), where an individual perceives stimuli. If used, these stimuli move from the perceptual memory to the working memory until they are stored in the long-term memory (Gazzaniga, 2018). This knowledge is kept in different categories, so-called schemata, which get updated and refreshed over a person's life span (Thorndyke & Hayes-Roth, 1979). Interactions with others can help us learn and update our knowledge and, therefore, assist us in adapting to new environments (Bandura, 1999, as cited in Mccormick & Martinko, 2004).

Scope of the Project

The central research question guiding this project is: How do sociomaterial and cognitive approaches differ in their understanding of online learning experiences, and what implications do these differences have for the design and effectiveness of online education? This paper will investigate these contrasting perspectives to provide a deeper understanding of the multifaceted nature of online learning and inform efforts to enhance the quality and inclusivity of digital learning environments.

Analysis

This analysis examines the sociomaterial and cognitive paradigms in online learning. Given the wide variety of these paradigms, it is acknowledged that this paper cannot cover all existing literature or represent the full range of perspectives within each approach. We will explore how each paradigm defines technologies, beginning with the sociomaterial perspective, which includes the intra-relationship between human and non-human actors. Next, we will explore the cognitive approaches, focusing on how technologies are designed to aid cognitive processes and reduce the learning load on students. We will then compare the paradigms in terms of engagement and motivation, highlighting the different approaches each paradigm adopts. Finally, we will address the concept of embodiment and attention in online learning.

Technologies

Understanding how technologies are perceived in these two paradigms is crucial in order to understand their perspectives on online learning. Firstly, Gourlay's (2021) definition of a technological tool provides insight into a better understanding of a digital object from a sociomaterial perspective. Although her definition focuses on digital systems, the conclusions drawn in this section can be extended to both digital and non-digital technologies. Gourlay explains that a digital system is composed of physical hardware, logical objects like data, and conceptual objects such as digital photos. Therefore, the materiality of a digital computer results from the interplay between these components, its physical properties and the way these components interact and are utilised (Gourlay, 2021).

Building on this understanding, sociomaterialists emphasise the intra-relationship between technologies (the non-human) and human actors (Barad, 2003; van den Berg & Verster, 2022). They reject the idea of technologies functioning purely as tools at the disposal of humans but view them as part of an interdisciplinary network of human and non-human actors (Gherardi, 2017; van den Berg & Verster, 2022). Consequently, the focus shifts to the relational enactment of all actors, highlighting the interdependence of actors rather than viewing them separately in knowledge creation (Barad, 2007, as cited in van den Berg & Verster, 2022). Within the sociomaterial paradigm, the concept of a continuous feedback cycle regarding online learning is emphasised, illustrating the ongoing and dynamic nature of the relationship between technologies and learning processes. Human actors, like teachers, and non-human actors, such as digital tools, all have an equal share in the responsibility to contribute to the success of this feedback cycle (van den Berg & Verster, 2022).

From this perspective, online learning combines social aspects, such as human interactions, with material aspects, like the internet, to create a *technology-mediated* *education* (Garbutt & van den Berg, 2022). Garbutt and van den Berg (2022) describe it as follows: "Online learning combines teaching and learning using information and communication technology to varying degrees. Thus, online learning may be analysed as imbrication or constitutive entanglement" (p.13). They describe online learning as a networked activity rather than an individual one.

Transitioning from online learning to a broader perspective on learning with technologies, Sørensen (2007) examined students' learning processes and observed that materiality is not just a mere trigger or mediator but an integral part of the learning process, continuously evolving with each interaction (Hasse, 2019, as cited in Pischetola et al., 2021; Schlauch, 2020). This shifts the role of technology from being a tool to an active participant in developing teaching practices (Pischetola et al., 2021; Schlauch, 2020). Technologies have the ability to either slow down or speed up educational processes, thus redefining work development and illustrating the interconnectedness of people and networks. They intra-act rather than inter-act (Barad, 2003; Pischetola et al., 2021). Thus, technologies are active agents of the learning process, and no assumptions are pre-given from a fixed form of learning; instead, they arise from the network that is part of the learning process (Gherardi, 2017; Pischetola et al., 2021).

Turning to cognitive approaches, they define technologies differently, focusing on the cognitive processes involved in learning (Winn, 1982). These cognitive processes, including working memory, *cognitive load*, and *dual coding theory*, are essential for effective information processing and retention. Understanding these processes is necessary to improve learning outcomes, especially when using educational technology. We will explore these processes further in the engagement section. For now, it is important to recognise that each human sense has limited processing capacities and overloading one can hinder effective learning (Namestovski & Kovari, 2022; Paas & Sweller, 2014). Therefore, engaging multiple senses simultaneously can prevent cognitive overload and enhance information processing and retention (Namestovski & Kovari, 2022). Technology design should incorporate multimedia elements, such as text, sound, and images, to engage multiple human senses concurrently (Darejeh et al., 2022; Namestovski & Kovari, 2022). Based on this knowledge, one of the most effective ways to process the curriculum is to display it using multimedia so that the learner acts on multiple senses. Thus, technology, such as online learning environments, is nothing more than a tool to help humans learn (Darejeh et al., 2022).

Building on this understanding of the role of technology, the “active” human plans and creates the student activity beforehand, and technology is a tool to act out these intentions (Namestovski & Kovari, 2022). The identity and role of the teacher thereby remain key in the educational process, and cognitivists see the teacher-student relationship as having the most significant impact on learning outcomes (Tomlinson & McTighe, 2006, as cited in Namestovski & Kovari, 2022). The most effective learning experiences occur when they directly connect to students’ existing knowledge and life experiences. However, often, teachers lack the necessary tools to facilitate this kind of connection.

To address this gap, cognitivists constructing online learning environments try to create a tool that makes it easier for learners to concentrate on the target task and engage with the material that is supposed to be learned (Darejeh et al., 2022). Unlike sociomaterialists, cognitivists do not attribute agency to technologies. Thus, technologies cannot draw or sustain human attention, as these processes require active effort from the learner (Namestovski & Kovari, 2022). Instead, technologies function solely as intermediating tools that can minimise cognitive load, allowing learners to extend the time they can focus on the material ahead (Namestovski & Kovari, 2022). Therefore, it is crucial to tailor online learning tools to individual cognitive abilities and needs, as the effectiveness of online learning depends heavily on the right tools for each student (Zhao, 2023).

In short, cognitivists typically view technology as a helpful tool that efficiently transports already-established knowledge from teacher to student. Sociomaterialists, however, see technologies as active agents in learning, with learning outcomes developing through the interaction, referred to as intra-action, between human and non-human actors. According to sociomaterial theories, technologies are equal actors within the educational environment, influencing and being influenced by humans. This comparison reveals fundamental differences in how each paradigm understands the role and impact of technologies in learning environments.

Engagement and Motivation

Understanding these differences is essential for examining how each paradigm views engagement and motivation with online technologies. One needs to examine their main assumptions about learning, cognition, and technology's role in these processes to understand the differences and similarities in how the cognitive and sociomaterial paradigms view engagement and motivation with online technologies.

Both paradigms recognise the importance of the design of technology in enhancing learning, agreeing that it is crucial in modern education and can significantly impact the learning experience (Garbutt & van den Berg, 2022; Namestovski & Kovari, 2022). Therefore, they understand that technologies should be designed with the learning activity in mind. The designs of these two paradigms, however, might differ. Sociomaterilists emphasise interactional (intra-actional) richness (van den Berg & Verster, 2022). More specifically, van den Berg and Verster (2022), who adopt a sociomaterial perspective, discuss creating a learning environment that recognises the impact of all individuals and elements through connected interaction. The approach involves engaging students through polls, small group discussions, and brainstorming sessions, fostering their active participation in the dynamic interplay between the social and material aspects of the environment, ultimately enhancing their learning experience. This method allows students to exchange knowledge and skills with each other, thereby enhancing the overall knowledge of the entire group (van den Berg & Verster, 2022). Sørensen's study (2007) illustrates this concept of connected interaction with an example: understanding whether a jump is long or short requires both the act of jumping and a ruler to measure distance. She connects this idea to online learning environments, suggesting that incorporating "real-world" elements, such as interactive simulations or virtual lab equipment, into virtual spaces enriches the learning environment's identity. Sørensen concludes that virtual learning environments and the real world form an interconnected system where each element mutually influences the other. Thus, an online learning environment, regardless of type, is an active actor and an equal part in creating learning (Sørensen, 2007; Schlauch, 2020). Therefore, this paradigm understands learning as developing from the intra-action and entangled relationship between human and non-human actors (Barad, 2003; Gherardi, 2007). Thus, creating an environment rich in intra-action creates a greater chance of learning.

In contrast, cognitivists focus on designing an online learning environment that creates cognitive ease (Darejeh et al., 2022). The analyses within this paradigm examine human cognitive abilities, such as working memory, cognitive load, dual coding theory, and individual learning styles (Darejeh et al., 2022; Gazzaniga, 2018; Namestovski & Kovari, 2022; Zhao, 2023). Limitations in an individual's working memory or cognitive abilities influence the effective learning outcome (Gazzaniga, 2018). *Cognitive load theory* helps us understand working memory's limitations as it highlights the limited capacity of our ability to process information. According to this theory, it is crucial to be mindful of not overwhelming students' information processing capabilities (De Jong, 2010, cited in Namestovski & Kovari, 2022; Paas & Sweller, 2014).

Therefore, online tools should be simple. Too much information can overload the working memory before the learner reaches the part of the material they want to learn, thereby decreasing efficiency (Gazzaniga, 2018; Namestovski & Kovari, 2022). Darejeh et al. (2022) created an online learning environment and found that animations can help humans learn by observing instead of only reading material. This supports the idea that using only one sense can overwhelm a part of the working memory by not using other senses to reduce this overload. Thus, from a cognitive perspective, technology should be designed as a tool that makes learning more efficient and reliable with less effort for the learner (Darejeh et al., 2022).

In addition to these design principles, both paradigms value learners' active engagement, though they approach it differently. Cognitive approaches focus on mental engagement, where the individual decides to learn and then focuses on the task (Winn, 1982; Zimmerman, 2000). The design of aiding technology and individual cognitive abilities determine how long a learner can engage before becoming tired or overwhelmed by the input (Darejeh et al., 2022; Namestovski & Kovari, 2022). In this view, technology does not directly engage the learner but serves as an aid in maintaining engagement, thus playing a passive role (Darejeh et al., 2022). Active student engagement is crucial to maintaining attention on the task, which can be enhanced with educational video questions (Namestovski & Kovari, 2022). This perspective highlights that without the learner's active decision and will, the tool cannot attract or maintain their attention; the learner's willingness allows the tool to help sustain focus on the task (Zimmerman, 2000). Here, the emphasis is on the human actor as the decision-maker (Namestovski & Kovari, 2022).

Sociomaterial approaches, on the contrary, emphasise interactional engagement (Schlauch, 2020; van den Berg & Verster, 2022). From this perspective, engagement occurs due to the entanglement of material and human actors. The four quadrants of online learning from Bratteteig and Verne (2012a, as cited in Garbutt & van den Berg, 2022) give better insight into how this entanglement influences students' engagement. If the social factors, such as collaboration and interaction, are easily accessible and the technology used for learning, that is, the material factors, work well, then the student learning outcome/experience will be good. Students taking part in Bratteteig and Verne's study described that they had fun and had no problems staying engaged with the task. However, if either of these factors, the social or material, becomes too complex, their engagement in the task decreases. Thus, only a well-functioning interplay of human and non-human actors can achieve the desired engagement for a good learning outcome.

Furthermore, sociomaterialists suggest that materials have the ability to draw children's attention towards them (Sørensen, 2007). For example, the central position of a blackboard in a classroom captures the students' attention, allowing the teacher to engage them by writing on it. Thus, the teacher and blackboard constitute a hybrid unit that makes it possible for the students to engage in the learning process more efficiently by interacting with the teacher and the material units in the environment (Sørensen, 2007). In the context of online learning, the active role of technologies is more evident. There, technologies protect users from viruses and connect them to thousands of online websites (Pischetola et al., 2021) without requiring active human participation. Almost all our engagement and interaction with others are mediated through objects of one kind or another (Gourlay, 2021; Gourlay & Oliver, 2018). Gourlay explains: “For instance, I speak to you through a text, even though we will probably never meet. And to do that, I am tapping away at a computer keyboard” (Gourlay & Oliver, 2018, p.2). This shows that engagement is an intra-action between human and non-human actors. One can influence the other, and neither of these actors exists alone or without the other. Their entanglement creates engagement and knowledge, thereby, learning outcomes.

To summarise the key points discussed, the cognitive paradigm views learning primarily as an internal mental process (Mccormick & Martinko, 2004; Winn, 1982; Zimmerman, 2000), focusing on how well the learner’s cognitive processes are activated and utilised during learning activities (Zhao, 2023; Zimmerman, 2000). Engagement with online technologies in this paradigm is centred on how these technologies help cognitive functions such as attention, memory, and problem-solving (Darejeh et al., 2022; Namestovski & Kovari, 2022). Therefore, cognitive theorists focus on designing technologies that minimise cognitive load (Namestovski & Kovari, 2022), enhance memory through multimedia learning (Namestovski & Kovari, 2022), and support metacognitive strategies (Zhao, 2023). In essence, technology is viewed as a tool designed to align with and support the workings of the human mind.

Contrasting with the cognitive approach, the sociomaterial paradigm does not distinguish between humans and technologies (Decuypere & Simons, 2016); instead, it views them as entangled in the learning process (Barad, 2003; Fenwick, 2015; Schlauch, 2020). Engagement, here, is the interaction between human and non-human actors, where both are considered active participants in the learning process (Orlikowski, 2007; Pischetola et al., 2021). This approach suggests that learning outcomes emerge from these interactions, emphasising the interconnectedness of learning (Hasse, 2019, as cited in Pischetola et al., 2021; Gherardi, 2017). Sociomaterialists are interested in how technologies and humans co-constitute each other, focusing on how social practices and interactions shape and are shaped by technological designs (Sørenson, 2007).

Embodiment and Attention

In learning, physical and sensory experiences influence interaction and engagement with the learning material. The concept of embodiment examines how these experiences are rooted in the body's interaction with the world (Skulmowski & Rey, 2018). During online education, embodiment describes how the student's physical presence, gestures, and movements influence their attention, engagement, and overall learning experience (Skulmowski & Rey, 2018; Weisberg & Newcombe, 2017).

Cognitive Approaches to Embodiment

Building on the concept of embodiment, cognitive approaches focus on how sensory inputs and motor actions enhance learning and attention, emphasising the brain's role in knowledge construction (Skulmowski & Rey, 2018; Weisberg & Newcombe, 2017). Humans use multiple senses to form coherent representations of their environment, relying on various neural structures working together (Skulmowski & Rey, 2018; Weisberg & Newcombe, 2017).

This sparked an interest in learning content that appeals to several neural structures. For example, Skulmowski and Rey (2018) examined how gestures and enactments in different learning settings influence performance. Gestures, defined as nonverbal representational movements, play a significant role in learning (Weisberg & Newcombe, 2017). Research showed that children who used gestures to explain or learn abstract tasks performed better on tests than those who did not (Skulmowski & Rey, 2018; Weisberg & Newcombe, 2017). Therefore, gestures remain important throughout life as a crucial aspect of embodied learning (Kontra et al., 2012, cited in Skulmowski & Rey, 2018). Acting out a story helps children understand it better (Glenberg, 2011, as cited in Skulmowski & Rey, 2018; Glenberg et al., 2004, as cited in Skulmowski & Rey, 2018), and motor experiences for infants improve their mental representations of objects (Weisberg & Newcombe, 2017). Thus, integrating sensorimotor processes into structured lessons enhances learning outcomes (Skulmowski & Rey, 2018; Weisberg & Newcombe, 2017).

Furthermore, analogies support learning by connecting unfamiliar ideas with familiar ones, promoting the development of new insights (Gentler, 1983, as cited in Weisberg & Newcombe, 2017). Hence, embodied learning tools should follow this principle, using actions and gestures to improve analogical reasoning.

To understand what sort of technologies allow learners to use gestures or bodily enactments, Johnson-Glenberg et al. (2014, as cited in Skulmowski & Rey, 2018) differentiated between four levels of technology. Lower levels of technology involve basic computer interactions, while higher levels use motion-tracking devices for full-body integration, leading to better learning outcomes. This distinction is supported by additional studies, which show that interactive conditions result in greater learning gains than non-interactive conditions (Weisberg & Newcombe, 2017).

Taking this further, Skulmowski and Rey (2018) distinguished between incidental and integrated embodiment. Incidental embodiment uses cues to influence cognition, while integrated embodiment is closely tied to learning tasks, resulting in better performance. A related concept, c*ognitive offloading,* enables learners to store information externally, freeing mental resources for problem-solving and explaining concepts (Weisberg & Newcombe, 2017). This natural tendency for cognitive offloading involves modifying the environment to save cognitive resources (Kirsh & Maglio, 1994, cited in Weisberg & Newcombe, 2017).

Thus, a taxonomy of two factors - integration (incidental vs. integrated) and bodily engagement (low vs. high) - influences embodied learning outcomes. Highly integrated types of embodiment with high bodily engagement lead to the best learning results.

In summary, cognitive approaches to embodied learning emphasise integrating sensory and motor experiences to enhance cognitive processes and learning outcomes. This paradigm views the brain as central to processing and integrating sensory inputs and motor actions, thereby constructing knowledge. Gestures and physical movements increase understanding and memory of abstract concepts by externalising cognitive processes and managing cognitive load (Skulmowski & Rey, 2018; Weisberg & Newcombe, 2017). Technologies supporting high bodily engagement, such as motion-tracking devices, create interactive learning environments, showing the importance of sensory-motor activities in increasing learning outcomes (Skulmowski & Rey, 2018; Weisberg & Newcombe, 2017).

Sociomaterial Approaches to Embodiment

Unlike cognitive approaches, which emphasise how sensory inputs and motor actions enhance learning, the sociomaterial paradigm focuses on the embodiment of humans within online learning environments (Bolldén, 2016a, 2016b). Sociomaterial analyses explore how individuals embody their presence in virtual settings and how this embodiment, along with human intentions, contributes to achieving pedagogical goals and learning outcomes (Bolldén, 2016a, 2016b; Garbutt & van den Berg, 2022; van den Berg & Verster, 2022). Thus, sociomaterialists see the body as not just a physical entity but an active participant in the social and material environment.

Even though some online environments are only text-based, researchers from the sociomaterial paradigm agree that engagement with online environments creates an online body (Bolldén, 2016a). These can be textual bodies in text-based online settings (Boellstorff, 2008, as cited in Bolldén, 2016a) or profile bodies in online settings with both text and photographs (Boyd, 2008, as cited in Bolldén, 2016a). In more interactive settings, Taylor (2002, as cited in Bolldén, 2016a) describes the avatar of students or teachers as the material ground out of which relationships and interactions are embodied. This kind of relationship shows the connection between the offline and online body. Thus, a body can be more than one, manifested in different settings and various forms (offline and online) (Mol, 2002, as cited in Bolldén, 2016a).

How do an actor's different types of bodies connect with each other? Material arrangements involve various entities, including humans and artifacts, engaging in different social relations, particularly intentionality and prefiguration. Intentionality refers to the expression of thoughts, actions, feelings, or understandings directed from one entity to another (Schatzki, 2002, as cited in Bolldén, 2016a). Prefiguration, however, involves arranging activities to increase or decrease the likelihood of their occurrence. These concepts highlight the importance of bodies and embodiment (Bolldén, 2016a).

In online environments, teachers and students interact extensively with digital objects, which are part of the material arrangement (Bolldén, 2016b). Since human entities are integral to this arrangement, their bodies are also considered material entities (Schatzki, 2012, as cited in Bolldén, 2016a). Consequently, bodily actions play a crucial role in achieving a person's goal. The relationship between human bodies and non-human artefacts suggests human actions can be augmented or enhanced by various forms of extensions or prostheses (Bolldén, 2016a; Garbutt & van den Berg, 2022; Gourlay & Oliver, 2018; van den Berg & Verster, 2022). Schatzki (2002, as cited in Bolldén, 2016a) uses the concept of a cyborg to illustrate this. In online settings, pixels on the screen, combined with human intentions or voices through a headset, allow the avatar to speak. This demonstrates that virtual objects are just as material and real as physical ones, and learning in online settings can be seen as engaging with and through virtual materiality (Bolldén, 2016b).

As these online and offline bodies overlap, malfunctions and breakdowns can occur (Bolldén, 2016a), separating offline and online bodies. Therefore, embodying an avatar can be seen as a constant shift between the dimensions of having a physical form and existing in a virtual space. Bolldén (2016a) explains this concept, stating that: "when no malfunction occurs, but there is a greater degree of overlap between the online body and offline body, this can be understood as being the online body" (p.8). Consequently, one must understand that the material arrangement and embodiment levels are unstable, and the entire network is influenced by its interaction (Bolldén, 2016a, 2016b; Gherardi, 2017; Pischetola et al., 2021). This highlights that online practices are linked to offline settings and bodies, requiring the management of both.

After having clarified how humans are embodied in online settings, we can assess how these online bodies can be used to achieve pedagogical goals. In online settings, human and non-human actors are interconnected, establishing roles, relationships, and meanings (Schatzki, 2002, as cited in Bolldén, 2016b). These arrangements are dynamic and not stable; the relationships, positions, and meanings of each actor can change. Human intentions and non-human actors' contributions influence this instability. Therefore, online arrangements, such as virtual classrooms, can be understood as fluid spaces that change according to their arrangement (Barad, 2003; Bolldén, 2016b; Gherardi, 2017; Montessori, 20004, as cited in Schlauch, 2020; Orlikowski, 2007; Pischetola et al., 2021).

For example, organising a working group folder for student discussions creates an online space. The teacher's intentionality influences the setup, such as leaving the folder relatively empty with only a few instructions and materials to encourage specific discussions.

This arrangement of the non-human entity affects how students interact with the folder, giving meaning to the space and instructions provided. Therefore, the teacher's intentions and the organised arrangement together give meaning to what was previously an empty space in an online context, forming a "co-constitutive relationship" (Bolldén, 2016b, p.10). However, teachers' attention alone cannot determine online activities. This becomes clear in the study of Bolldén (2016b), where the absence of a designated space in an online setting, a folder for questions, resulted in these activities emerging elsewhere. Thus, learning practices and outcomes unfold during the process and are not predetermined (Bolldén, 2016b; Gherardi, 2017; Schlauch, 2020; van den Berg & Verster, 2022).

In addition, in virtual online settings, such as an online world where users move as embodied in avatars, the teacher can adjust the students' position by giving verbal instructions or directing attention to specific elements. This modification alters how students interpret the open spaces in the virtual world (Bolldén, 2016a, 2016b). It becomes evident that arrangements and learning outcomes are not fixed but emerge from the intra-action of material and social factors. Any changes in online environments result in changes in human behaviour and vice versa. Accordingly, learning is neither pre-constructed nor happens the same way in every setting; it emerges from the network intra-action (Barad, 2003; Bolldén, 2016b; Gherardi, 2017; Pischetola et al., 2021; Schlauch, 2020) and is equally influenced by human and non-human actors.

Discussion

This paper discussed two distinct paradigms regarding online learning - the sociomaterial and cognitive approaches. These approaches help us better understand the design and implementation of effective online educational technologies. The main research questions guiding this discussion are: How do sociomaterial and cognitive approaches differ in their understanding of online learning experiences, and: What implications do these differences have for the design and effectiveness of online education?

Firstly, we summarise this paper's findings to restate the implications for technologies and engagement. Then, we will focus in more detail on the implications for the teacher's role in each paradigm. Last, we will address the study's limitations and areas requiring further research.

Regarding the design of online learning technologies, cognitive approaches view technology as a tool that transports already-established knowledge from teacher to student (Darejeh et al., 2022). Technologies support learning by reducing cognitive load and enhancing individual learning efficiency (Namestovski & Kovari, 2022; Pass & Sweller, 2014). Thus, integrating multimedia elements such as text, sound, and images can engage multiple senses, preventing cognitive overload and improving higher cognition (Darejeh et al., 2022; Namestovski & Kovari, 2022; Paivo & Clark, 2006, as cited in Namestovski & Kovari, 2022). The dual coding theory, which supports using verbal and non-verbal elements to enhance learning, underscores the importance of designing technologies that align with cognitive abilities (Darejeh et al., 2022; Namestovski & Kovari, 2022; Paivo & Clark, 2006, as cited in Namestovski & Kovari, 2022). Thus, this paradigm focuses on not overwhelming the individual by keeping their cognitive abilities in mind. Consequently, technologies are seen as tools that enhance learning and should be created to help carry information to students efficiently.

In contrast, sociomaterialists see technology as an active participant in learning. Learning outcomes emerge from the intra-action between human and non-human actors (Barad, 2003; Bolldén, 2016b; Gherardi, 2017; Schlauch, 2020; van den Berg & Verster, 2022; Pischetola et al., 2021). These non-human actors are equal participants in the learning process, influencing and being influenced by humans (Gherardi, 2017; van den Berg & Verster, 2022). Accordingly, this paradigm views learning as a cyclical, interconnected process within a larger network (Barad, 2003; van den Berg & Verster, 2022). Consequently, technologies should be designed to foster rich intra-actions, enhancing engagement by creating dynamic interactional spaces. While technologies can be designed to increase the likelihood of preferred outcomes, the interactions between human and material agents remain dynamic and unpredictable (Bolldén, 2016a). Therefore, sociomaterialists focus on a design that allows rich intra-actions between human and non-human actors to create a greater chance of learning.

Having discussed the design of online technologies, how do these paradigms differ in their understanding of how engagement with these technologies works? Cognitivists view learning as an internal mental process (McCormick & Martinko, 2004; Winn, 1982; Zimmerman, 2000), emphasising the activation and use of cognitive processes during learning activities (Zhao, 2023; Zimmerman, 2000). In this paradigm, engagement is centred on the individual's intention (Darejeh et al., 2022; Namestovski & Kovari, 2022; Zimmerman, 2000). Technologies support this process by minimising cognitive load, enhancing memory through multimedia learning, and supporting metacognitive strategies (Namestovski & Kovari, 2022; Zhao, 2023). Thus, well-designed technologies, aligning with cognitive processes, enable longer interaction without fatigue.

On the contrary, sociomaterial approaches view engagement as resulting from the entanglement of material and human actors, both active participants in the learning process (Barad, 2003; Decuypere & Simons, 2016; Fenwick, 2015; Gherardi, 2007; Schlauch, 2020). Learning outcomes emerge from the interactions between these actors rather than being transmitted from technology to learner (Orlikowski, 2007; Pischetola et al., 2021). This approach emphasises the co-constitution of technologies and humans, focusing on how social practices and interactions shape and are shaped by technological design (Sørensen, 2007). In doing so, sociomaterialists aim to design environments that create rich interactional spaces, enhancing engagement and learning outcomes (van den Berg & Verster, 2022; Sørensen, 2007). As mentioned previously, these environments can be built and arranged intentionally to increase the chance of favoured outcomes. However, the dynamic nature of these interactions means they cannot be fully controlled.

Implications for the Role of the Teacher

Given the varying degrees of control individuals have over the learning process and engagement with online technologies in these paradigms, there are different implications for the importance of the teacher's role in each paradigm. The cognitive paradigm describes learning as an internal cognitive process in the brain (Mccormick & Martinko, 2004; Winn, 1982; Zimmerman, 2000). This approach sees technologies as mere tools to transport pre-established knowledge to learners engaging in the online learning environment. This implies that the ease with which students can engage with online learning technology directly influences how well they grasp and memorise the content (Darejeh et al., 2022; Namestovski & Kovari, 2022; Zhao, 2023; Zimmerman, 2000). Therefore, teachers play a central role alongside learners, creating and providing knowledge to be comprehended. Without the teacher, the technology would lack purpose, as there would be nothing that this tool could transport to the individual engaging with it. Thus, teachers are crucial in creating and delivering content that connects to students' prior knowledge and experiences, facilitating effective learning outcomes (Tomlinson & McTighe, 2006, as cited in Namestovski & Kovari, 2022). Consequently, there is a need to focus on better training so that teachers can effectively use technology in their instructional design and delivery. Teachers should be able to use technologies to transport their knowledge to students, directly connecting to their previous knowledge and experiences. The more skilled and trained the teacher is, the more effective the learning outcome will be.

While cognitivists view teachers as the main actors in creating and delivering learning goals, sociomaterialists view knowledge creation and delivery as emerging from the interaction within a network. From a sociomaterial perspective, teachers act as connectors within the network of human and non-human actors, influencing learning outcomes through their interactions and intentions, thereby stimulating a collaborative learning environment (Montessori, 2004, as cited in Schlauch, 2020). As knowledge arises from the interactions within a network, teachers can only try to influence how students engage with technology. This intentional prefiguration involves the arrangement of activities to make them more or less likely to happen (Bolldén, 2016a). Gaps in the design of technologies, different arrangements, or different participants within a network will always create a varied learning outcome, and the interaction between these different actors influences the knowledge-creation process.

In summary, the cognitive approach provides clear practical implications: technologies should be designed to reduce cognitive load, support individual processes, and teachers should be trained to integrate these tools effectively into their teaching. Practical applications include developing multimedia-rich educational materials and training programs for teachers to enhance their technological pedagogical content knowledge, as suggested by Mishra and Koehler (2006).

In contrast, the sociomaterial approach is more of a theoretical nature (Fenwick & Edwards, 2010, Chapter 1), providing a framework that emphasises the entanglement of human and non-human actors in learning processes. It offers less direct practical guidance but encourages integrating diverse perspectives and continuously adapting educational technologies. This approach suggests that empirical research should explore how various interactions influence learning outcomes, guiding the development of flexible, interaction-rich learning environments. Both paradigms offer valuable insights into the designing and implementing online educational technologies. Integrating these approaches can lead to more effective and inclusive online learning environments, ultimately enhancing student engagement and learning outcomes.

Limitations

Even though valuable insights were gained from this research, it is important to acknowledge its limitations. This study was purely based on a literature analysis, which restricts the depth of understanding that can be achieved compared to empirical studies and prohibits us from drawing any causal conclusions. The analysis relied on existing literature and secondary data, which may not fully capture the latest developments or all aspects of this fast-growing field of research on online learning. Additionally, the research was restricted in that it was limited to the database of the University of Groningen, potentially excluding relevant studies and viewpoints that could further enrich the findings. Literature from the sociomaterial approach is primarily based on observational data and theoretical frameworks. Specific experiments are required to establish causal relations within this paradigm.

Further research

Future research will face several challenges. In the cognitive paradigm, one challenge lies in designing cognitive-friendly technologies that effectively reduce cognitive load without oversimplifying the content. These designs should focus on innovative ways to balance cognitive ease with content-rich environments. Furthermore, the successful training of teachers should be emphasised.

For sociomaterialists, the challenge is to develop frameworks that facilitate dynamic interactions between human and non-human actors and explore how these interactions impact learning outcomes. Additionally, there is a need to create experimental studies to make more causal claims about the effects of these interactions. Both paradigms need to address the concept of distractions. Although this topic has been extensively studied, future research should consider these findings, which were beyond the scope of this study. Finally, future research should combine the different implications that can be drawn from these paradigms and diminish the limitations of this study.

Conclusion

This research explored the differences between sociomaterial and cognitive approaches in understanding online learning experiences, focusing on their implications for the design and effectiveness of online education. The rapid shift to online learning since the COVID-19 pandemic has shown the need for effective online educational technologies. By examining these two paradigms, this study aimed to provide a deeper and more coherent understanding of online education.

It becomes evident that cognitive approaches focus on the individual and their mental processes, such as working memory, cognitive load, and dual coding theory, in the process of learning (Darejeh et al., 2022; Gazzaniga, 2018; Paivo & Clark, 2006; Namestovski & Kovari, 2022; Zhao, 2023). Thereby, the teacher's role remains crucial in creating and delivering content, with technologies serving as tools to transfer knowledge from teacher to student (Tomlinson & McTighe, 2006, as cited in Namestovski & Kovari, 2022). Effective technologies should facilitate student engagement with the material and incorporate multimedia elements to engage multiple senses, preventing cognitive overload and enhancing learning outcomes (Darejeh et al., 2022; Namestovski & Kovari, 2022; Paivo & Clark, 2006, as cited in Namestovski & Kovari, 2022). The emphasis is on the learner's active decision-making, with technologies as mere tools extending this engagement process (Darejeh et al., 2022; Mccormick & Martinko, 2004; Namestovski & Kovari, 2022; Winn, 1982; Zhao, 2023; Zimmerman, 2000).

In contrast, sociomaterial approaches view learning as an interconnected process involving social and material factors without distinguishing between human and non-human actors (Decuypere & Simons, 2016). Learning outcomes emerge from the intra-action between these entities rather than being pre-established (Bolldén, 2016b; Gherardi, 2017; Schlauch, 2020; van den Berg & Verster, 2022). Thus, these approaches give technologies an active role in shaping the learning process, contributing to the dynamic and ever-changing educational environment (Gherardi, 2017; Pischetola et al., 2021; Schlauch, 2020; van den Berg & Verster, 2022). This paradigm highlights the significance of interactional engagement, where learning outcomes arise from the entangled relationships between human and material actors (Sørensen, 2007). In short, they focus on creating rich interactional spaces to enhance engagement and learning outcomes (Garbutt & van den Berg, 2022; Sørensen, 2007). They move away from the idea of the human as the only active participant in the learning process and thereby also see the role of teachers more as a "connector" within the network rather than a creator of knowledge.

In conclusion, while the cognitive and sociomaterial paradigms offer distinct perspectives on online learning, integrating both paradigms can lead to more effective and inclusive educational experiences. Future research must explore how integrating the strengths of both these paradigms can enhance the quality and inclusivity of online learning experiences.

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